AMBIENT AIR QUALITY IN THE SARNIA AREA

1972 to 1977

Ontario
Ministry of the Environment

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IN THE

SARNIA AREA

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Technical Support Section
Southwestern Region

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SUMMARY

With the exception of ozone and fluoridation rates in the area south of Courtright, there has been a trend of improvement in the levels of pollutants that exceed the criteria for desirable ambient air quality. For pollutants not exceeding the established criteria, trends toward increased levels have not been detected.

Ozone, which has been monitored in the Sarnia area since 1974, causes vegetation damage and too frequently has exceeded the criteria for desirable ambient air quality. However, much of the ozone is attributable to the transport of pollutants from outside the Sarnia area and therefore the achievement of acceptable levels of ozone will depend on control strategies for southern Ontario and neighbouring areas of the United States.

During 1977 the levels of sulphur dioxide demonstrated very significant improvements in the area immediately south of Courtright. This improvement is credited, in part, to better dispersion of and control of sulphur dioxide emissions from Detroit Edison's St. Clair Power Generating Station. A new control strategy is being developed by this Ministry in order to reduce the levels of sulphur dioxide in other sections of the Sarnia area, to acceptable levels.

Fluoridation rates above background levels and localized vegetation damage attributable to fluorides have been detected in the vicinity of the fertilizer plant of Canadian Industries Limited.

INTRODUCTION

The ambient air monitoring program operated by the Ministry of the Environment in the Sarnia area is designed to detect a number of pollutants which may directly or indirectly be harmful to human health, vegetation or property. The program also provides information on trends in levels of air pollutants and information useful in identifying pollution sources. Monitoring is most intensive in downtown Sarnia because that area is affected by emissions from industries and power plants to the south, as well as emissions from heavy automobile traffic and commercial establishments. It is therefore believed that most pollutants would attain or approach maximum concentrations in the downtown area.

In addition to the air monitoring program of the Ministry of the Environment a comprehensive monitoring network is operated by the Lambton Industrial Society and monitoring is also conducted by private industries and Ontario Hydro. Although this report does not discuss data obtained by these groups, these additional data have been used to substantiate and assist in the interpretation of Ministry data.

Monitoring was conducted in the Sarnia area by the founding organizations of the Ministry of the Environment in the 1960's; however, this report is restricted to data obtained for the years 1972 through 1977. These years have

been selected as being representative of more recent air quality conditions and also represent a period throughout which monitoring techniques have had consistent levels of accuracy. In earlier years, the precision of some monitoring instruments was not comparable with that of instruments of today.

DESCRIPTION OF MONITORING NETWORK

Throughout the Sarnia area the Ministry of the Environment operates a network of continuous and intermittent ambient air monitors. The locations of the Ministry stations are illustrated in Figure I, Appendix I and the specific locations (including elevations) are listed in Table I, Appendix I. The pollutants monitored at individual stations are also included in Table I.

Additions to the monitoring network during 1977 included an ozone monitor in a rural location west of Wyoming (station 14118), monitors for wind speed, wind direction, sulphur dioxide and sulphation rate in east Sarnia (station 14062), and a back-up sulphur dioxide instrument in downtown Sarnia (station 14049) to ensure immediate availability of the Air Pollution Index (API). Also during 1977, monitoring for sulphation rate at station 14055 in the industrialized area of southern Sarnia was terminated when construction in the immediate area necessitated relocation of the structure at which sulphation rate was measured.

The location of heavy industry and power generating stations close to the St. Clair River has resulted in the positioning of sources of air pollution emissions in a general north-south direction. As a result, southerly winds blow pollutants from a number of pollution sources simultaneously into Sarnia and elevated levels of pollution may result.

This additive impact of several sources of emissions along with the density of population, magnitude of vehicle emissions and commercial sources of pollution has resulted in air monitoring being conducted relatively intensively in the Sarnia area.

The Ministry of the Environment's criteria that reflect desirable air quality and the prime basis for these criteria are listed in Table II, Appendix I for those pollutants monitored in the Sarnia area.

METEOROLOGICAL DATA

Meteorological data are utilized in predicting the stability of the atmosphere and therefore the dispersion characteristics of the weather. These data are also utilized in tracking the most likely source or sources of elevated levels of pollution, and in validating mathematical models designed to simulate the dispersion of emissions of air pollutants.

At station 14016, located immediately south of Courtright, wind speed and wind direction are measured continuously at 10 metres, 62 metres and 92 metres above ground level. In addition, ambient air temperature is recorded at the 10-metre level and the temperature gradients between the 10-metre and the 62-metre levels and the 10-metre and the 92-metre levels are also recorded. The meteorological data obtained at station 14016 are telemetered every 5 minutes to Toronto where meteorologists utilize the

data to forecast the stability of the atmosphere. This forecasting feature is an intrinsic part of the Air Pollution Index reported for Sarnia.

In late March 1977, monitoring of wind speed and wind direction commenced at 10 metres above ground level at station 14062, located in east Sarnia.

Table III, Appendix II, contains the average frequency of wind direction determined at the 62-metre level at station 14016 for 1972, plus the years 1975 through 1977. The percent frequencies for various wind directions, expressed as percentages were very similar for the years reported. Data for 1973 and 1974 were improperly stored in the data bank of the computer. Correction of these data is currently being accomplished.

PARTICULATES

Particulates are emitted into the atmosphere in significant quantities by man, nature and the combined actions of man and nature. Combustion, material handling, and vehicle transportation are operations that result in man-caused emissions of particulates to the atmosphere. Volcanic eruptions, natural fires and wind erosion are examples of ways in which nature contributes air-borne particulates. However, wind erosion of ploughed fields and stock piles of coal, gravel and sand, as well as the re-entrainment by winds of man-made particulates that have settled on smooth surfaces such as roadways, parking lots and roofs, are means by which man and natures jointly contribute particulates into the atmosphere.

In the Sarnia area particulates in the ambient air are measured directly as dustfall and suspended particulates and indirectly as soiling index. Dustfall is calculated by exposing open-mouthed cylinders of known diameter for 30 days and subsequently weighing the amount of particulate gained per unit area. Suspended particulates are determined by drawing measured volumes of air through a filter for 24 hours with a vacuum pump and subsequently weighing in the laboratory the amount of particulates trapped on the filter. Soiling index is determined by drawing ambient air at a controlled flow rate through a filter for either 1 or 2 hours and measuring the change in the transmittance of light through the filter before and after the ambient air passes through the filter. Since the size, shape and mass of the particulates trapped on the filter will influence the amount of light that may be transmitted, soiling index may only be empirically related to the concentration of suspended particulates in the air. However, since dustfall and suspended particulates require laboratory analysis while soiling index may be calculated immediately by the monitoring instrument, soiling index is essential to the Air Pollution Index system which requires real time indications of levels of suspended particulates. Soiling index is expressed in units of Coefficient of Haze (COH) per 1000 feet of air.

To determine if there are excessive levels of specific particulates or a meaningful trend in the chemical content of suspended particulates, suspended particulates collected on filters at stations in the Sarnia area are analyzed for a variety of constituents.

Dustfall

The Ministry of the Environment's criteria for desirable ambient air with respect to dustfall are 7.0 grams per square metre per 30 days (gms/m^2/30 days) in any single month and an annual average dustfall loading of 4.5 gms/m^2/30 days. These criteria for dustfall are based on historical data and criteria established by other enforcement agencies.

Dustfall samples are collected at stations 14049 and 14051, both situated in downtown Sarnia. Measurements obtained for samples collected at station 14049 during 1977 reveal that the monthly criterion was exceeded only once when the dustfall loading was 8.7 gms/m^2/30 days and that the annual average of the dustfall loading was 4.7 gms/m^2/30 days which exceeds the annual criteria by a small margin. The dustfall measurements determined for samples collected at station 14051 reveal that both the annual and monthly criteria were met during 1977. A review of the dustfall data for stations 14049 and 14051 reveals no upward or downward trend in dustfall loadings. The dustfall data for both stations appear in Table IV, Appendix III.

Although the annual criterion for desirable ambient air quality has been exceeded at station 14049 for the past 5 years and in two of the past six years at station 14051 the dustfall loadings in downtown Sarnia should be considered acceptable. The excursions have been slight in magnitude and compare favourably with measurements determined in downtown areas of other communities.

Suspended Particulates

The criteria for desirable ambient air with respect to suspended particulates are 120 micrograms (ug) of suspended particulate per cubic metre (m^3) of air during the 24-hour period of midnight to midnight and an annual geometric mean of 60 ug/m^3. The criterion for 24-hours is based on impairment of visibility and the annual criterion is based on public awareness of pollution.

Samples for suspended particulate analyses were collected at 7 locations in the Sarnia area during 1977. As was the case in 1976 all but station 14049 reported annual geometric means for 1977 within the criterion for desirable ambient air. Excursions above the criterion for the annual geometric mean are common in the downtown areas of urban centres due to heavy traffic, construction, and other similar activities that generate and disturb particulate matter. Therefore the recording of an annual geometric mean above the criterion for desirable ambient air at one location (Station 14049) in downtown Sarnia does not reflect unusual or significantly deteriorated air quality.

The criterion for 24 hours was exceeded at 4 of the 7 monitoring sites in the Sarnia area. Frequencies of excursions of approximately 10 per cent may occur in rural areas due to wind erosion of soils and re-entrainment of settled particles. The 4 per cent frequency of excursion that occurred at station 14054 located in the residential area of north Sarnia was lower than experienced in any of the preceeding 5 years. Although it would be desirable to have lower frequencies of excursions recorded at the three

stations located in the downtown area (station 14001, 14049, and 14051) it is not realistic to expect the 24-hour criterion for desirable ambient air to be achieved continuously in downtown areas. In general, the levels of suspended particulates measured in the Sarnia area during 1977 are considered to be satisfactory.

Table V, Appendix III, contains a summary of the levels of suspended particulates determined in the Sarnia area from 1972 through 1977. The summary reveals that suspended particulates have been very significantly reduced since 1972 and 1973. This decreasing trend is also displayed in Figure II, Appendix III.

Detailed Chemical Analysis of Suspended Particulates

As part of a Province-wide study suspended particulate samples collected at various stations in the Sarnia area have been analyzed for cadmium, chromium, copper, iron, lead, manganese, nickel, nitrates, sulphates, vanadium and zinc. Table VI, Appendix III, contains a summary of this data. Because there is only a very limited amount of data available for 1972, data for 1971 have been included in Table VI.

Criteria for desirable ambient air quality exist for only cadmium, lead, nickel and vanadium. Table VI reveals that the concentrations of the various metals have been quite low and that there have been no values above the criteria.

The annual average concentrations reported for sulphates and nitrates indicate neither a decreasing nor increasing trend. However, the percentage of sulphate in suspended particulates is greater in Sarnia than percentages reported for other urban areas of Southwestern Ontario.

Soiling Index

The criteria for desirable ambient air quality with respect to soiling index are based on adverse health effects that may be created by combined concentrations of suspended particulates and sulphur dioxide. These criteria are 1.0 COH per 1000 feet of air averaged for the 24-hour period of midnight to midnight and 0.5 COH per 1000 feet of air averaged for 1 year.

In Sarnia the soiling index is measured at station 14049, located in downtown Sarnia. The annual criterion for desirable air quality has been achieved each year since 1972. The criterion for 24-hours was exceeded once in 1974 and twice in 1976 but on no other occasion when monitoring was conducted in the period of 1972 through 1977. The two excursions in 1976 were related to upset conditions at a source of pollution in the immediate vicinity of the monitoring station. The continuous monitoring and telemetering of soiling index data permitted immediate notification of the high levels of particulates and the source was quickly identified and corrective action implemented.

Since elevated concentrations of suspended particulates are most often reported for station 14049, it is reasonable to assume that soiling index levels recorded at that station would represent worse-than-average conditions

for the Sarnia area. Therefore, the recording of acceptable levels of soiling index at station 14049 suggests that soiling index values are in general at an acceptable level in the Sarnia area. A summary of the trend in soiling index values since 1972 is included in Table VII, Appendix III.

SULPHUR OXIDES

The combustion of sulphur-containing fossil and petroleum fuels is the largest man-made source of sulphur oxide emissions to the atmosphere . In the Sarnia area large quantities of these fuels are consumed by power generating plants located in both Michigan and Ontario and by the petroleum and petrochemical industries located to the south of downtown Sarnia. During combustion, the sulphur in the fuel is oxidized primarily to sulphur dioxide and emitted to the atmosphere in the flue gas. In the atmosphere some sulphur dioxide is oxidized to sulphate while some is absorbed by the ground and vegetation.

Sulphur oxides are monitored in Lambton County by this Ministry utilizing continuous sulphur dioxide gas analyzers, laboratory analyses of particulate matter for sulphate content (described in the section concerning detailed analyses of suspended particulates) and the sulphation rate technique. Sulphation rate is determined by exposing a filter coated with lead peroxide for a period of 30 days. During the 30-day exposure period oxidizable sulphur compounds in the ambient air react with the lead peroxide to form lead sulphate. The sulphate content on the filter is subsequently measured in a laboratory.

Sulphur Dioxide

Criteria for desirable ambient air quality are 0.25 parts of sulphur dioxide per million parts of air (ppm) as the average concentration for 1 hour, 0.10 ppm sulphur dioxide as the average concentration for the 24-hour period from midnight to midnight and 0.02 ppm sulphur dioxide as the average concentration over 1 calendar year. The criteria established for the 1-hour and annual periods are based on damage to vegetation while the criterion established for 24-hours is based on adverse effects to human health.

There are 4 monitoring stations in Lambton County at which this Ministry operates continuous sulphur dioxide gas analyzers. Two analyzers are located at sites south of Courtright in the vicinity of Ontario Hydro's Lambton Power Generating Station and Detroit Edison's St. Clair Power Generating Plant. A sulphur dioxide analyzer is also strategically located in downtown Sarnia such that it can detect the combined contributions of several sources of sulphur dioxide emissions located to the south of downtown Sarnia. On October 13, 1977 a sulphur dioxide monitor was placed in operation at Eastland Plaza, located in a commercial-residential area of east Sarnia.

During 1975 and 1976 the sulphur dioxide monitor housed in station 14004 south of Courtright reported relatively frequent excursions of the 24 and 1-hour criteria. The vast majority of these excursions were attributed to sulphur dioxide emissions from Detroit Edison's St. Clair Power Generating Station. Pollution abatement measures initiated

at the St. Clair Power Generating Plant resulted in very appreciable improvements in air quality during 1977. The data reported for station 14004 for 1977 reveal no excursions above the 24-hour criterion and the frequency of excursion above the 1-hour criterion was greatly reduced from previous years to 0.03 per cent.

The improvements at the St. Clair Power Generating Plant have probably contributed to the elimination of excursions of the 1-hour criterion at station 14016. During previous years excursions have been reported. With respect to the 24-hour criterion there have been no excursions reported for station 14016 since full scale monitoring began in 1973. Also, the criterion for annual average has not yet been exceeded at either station 14004 or 14016.

At station 14049 located in downtown Sarnia, the frequencies of excursions above the 1-hour criterion have been relatively low and have remained essentially the same since 1975. Prior to 1975, excursions were appreciably more frequent. The frequencies of excursions above the 24-hour criterion have been more consistent since 1972 and have not been reduced to an acceptable rate of occurrence. Almost all excursions above the 1-hour and 24-hour criteria at station 14049 have been connected with southerly winds. This is understandable because of the many sources of sulphur dioxide emissions located in a southerly direction from station 14049. The criterion for annual average was exceeded in 1974. Table VIII, Appendix IV, contains data representing the trend in sulphur dioxide levels from 1972 through 1977.

Pollution roses were constructed for sulphur dioxide data determined during 1977 at stations 14004, 14016 and 14049 utilizing the wind direction data measured at the 30-metre level of station 14016. These pollution roses, which appear in Figure III, Appendix IV, show that for station 14004 the highest average sulphur dioxide concentrations are associated with winds from the northwest and north-northwest sectors, the directions in which the power plants of Ontario Hydro and Detroit Edison are located. However, the average concentration from these sectors are well below the annual average criterion and, in general, levels reported for station 14004 were low during 1977.

For station 14016 the pollution rose indicates that the highest average concentrations of sulphur dioxide occur when winds are blowing from the north and north-north -east sectors the directions to which much of the industry Sarnia and some power generating sources in the Sarnia-Port Huron area are located. Also, the average concentration of sulphur dioxide associated with southerly winds is above the annual average reported for the station. This is not surprising since the Lambton Power Generating Station and the St. Clair Power Generating Station are located in a generally southerly direction from station 14016.

The pollution rose for station 14049 clearly illustrates the strong influence of the sulphur dioxide emission sources located in a south-south-east to south-

south-west sector from Sarnia. The lineal orientation of emission sources in this sector is also an important factor in excursions above the 1-hour and 24-hour criteria for desirable ambient air quality.

Sulphation Rates

The criterion for desirable ambient air with respect to sulphation rate is 0.7 milligrams of sulphur trioxide per 100 square centimetres of exposed lead peroxide per day (0.7 mg SO_3/100 cm^2/day). Sulphation candles are exposed for one month and the sulphation rate determined for the one month exposure period is adjusted to a daily value and compared to the criterion. This monthly criterion was established with the intention of it being compatible with the annual average concentration of sulphur dioxide, for which an ambient air criterion exists based on vegetation damage. However, there are too many different variables between the measurements for sulphation rate and the determination of annual averages for sulphur dioxide to provide a good correlation. Consequently, the sulphation rate measurements are best used to indicate relative amounts of oxidizable sulphur compounds in specific areas during a given year.

Sulphation rates were determined for 11 monitoring sites in the Sarnia area during 1977. The values reported for station 14049 and 14051, located in downtown Sarnia, reveal that area to have the highest sulphation rates outside of the industrialized area situated south of downtown Sarnia, where insufficient data were collected to be representative of the complete year.

Sulphation rates determined for 1977 appear in Table IX, Appendix IV. A comparision of annual average values and the percentage of values above the criterion for the years 1972 through 1977 appears in Table X, Appendix IV. The lack of an acceptable correlation between sulphur dioxide levels and sulphation rate for data representative of both monthly and annual data accentuates the limitations of utilizing sulphation rates to evaluate air quality.

AIR POLLUTION INDEX

On December 1, 1977 a formal Air Pollution Index (API) was introduced at Sarnia by this Ministry. The API is utilized in seven Ontario cities as an alerting system to control or prevent an air pollution epidose. Meteorological forecasting and current readings of sulphur dioxide and suspended particulates are used to predict the potential for the persistence of excessive levels of pollutants which are numerically reported as the API.

Data for suspended particulates collected by the standard high volume filter method at station 14049 in downtown Sarnia have been correlated with data for soiling index. This correlation permits the use of real time readings of soiling index in the calculation of the API. The concentrations of sulphur dioxide are provided by the continuous hourly readings obtained at station 14049. The data for soiling index and sulphur dioxide are telemtered along with meteorological data to a computer centre in Toronto where

the API is calculated as a running 24-hour average value using the following formula:

$$API=0.18\ (31.15\ COH+124.63\ SO_2)^{1.37}$$

where COH is the soiling index and SO_2 is the sulphur dioxide concentration expressed in parts per million.

API values calculated by this formula that are less than 32 are considered acceptable. Values of 32 to 49 are at the Advisory Level and if adverse weather conditions are likely to persist, major emission sources are advised to prepare to curtail operations. At an API of 50, major emitters may be required to curtail operations. At 75, further cutbacks can be required. When the API reaches 100 all man-made sources of pollution not essential to public health and safety may be ordered to discontinue operations.

The control of emissions of sulphur dioxide and suspended particulates during periods of elevated API values may simultaneously reduce the emissions of other pollutants normally emitted with the suspended particulates and sulphur dioxide. However, there may be occasions when there are high concentrations of other pollutants, such as ozone, and the API level will be acceptable. During these conditions the normal monitoring program of this Ministry would serve to detect the abnormal condition. The API is structured to control levels of pollution that could have immediate health effects and does not reflect the nuisance type of pollutant such as offensive odours.

During December 1977, the first month of operation, the API values were within the acceptable range. The maximum values recorded was 15.

HYDROGEN SULPHIDE AND MERCAPTANS

Hydrogen sulphide and mercaptans are measured collectively at station 14049 in downtown Sarnia. Mercaptans are a group of organic compounds that contain sulphur and hydrogen and exhibit characteristics similar to hydrogen sulphide. Hydrogen sulphide is commonly referred to as rotten egg gas and many mercaptans are also malodorous at extremely low concentrations.

Both hydrogen sulphide and mercaptans originate in nature from anaerobic decomposition of organic matter containing sulphur. In the Sarnia area, the release of hydrogen sulphide and mercaptans into the atmosphere may result from the processing of petroleum feedstocks containing sulphur.

The criterion established to represent desirable ambient air with respect to hydrogen sulphide is 0.02 ppm as an average for 1-hour. This criterion is based on the offensive odours exhibited by this gas. Similarily the criterion for mercaptans is based on odour and was established as 0.01 ppm averaged for 1 hour and expressed as methyl mercaptan.

Unfortunately the monitoring instrument in Sarnia does not segregate hydrogen sulphide from mercaptans but determines the total combined concentrations of hydrogen

sulphide and mercaptans and expresses this concentration in terms of hydrogen sulphide. Therefore, to adjust for this situation the combined concentration of hydrogen sulphide and mercaptans, as reported for station 14049, is compared to the criterion for hydrogen sulphide. The number of excursions above the criterion was reduced to 1 during 1977 which is a frequency rate of 0.01 per cent. The freqency of excursions has reduced continuously since 1974. This reduction may be attributed in part to better control of emissions from industry in the Sarnia area. A summary of the combined hydrogen sulphide and mercaptan results since 1974 appears in Table XI, Appendix VI.

CARBON MONOXIDE

Combustion processes that oxidize carbon to carbon monoxide are the most significant man-made sources of carbon monoxide. Of these processes, gasoline combustion in the automobile is the most critical because of the large amount of carbon monoxide emitted and poor dispersion due to the low level of exhaust. Large point sources of carbon monoxide such as power generating stations normally provide adequate dispersion for their emissions to prevent appreciable carbon monoxide build-up.

The criteria for desirable ambient air were established for carbon monoxide to protect human health. The criterion for 1-hour is 30 ppm and the criterion for any consecutive 8-hour period is 13 ppm.

The highest levels of carbon monoxide in the Sarnia area occurs in the downtown-commerical area of Sarnia since it is here that automobile traffic tends to be heaviest and provides emissions that combine with emissions of carbon

monoxide from power plants and industries. The levels of carbon monoxide that occur in downtown Sarnia are measured at station 14049, where the criteria have not been exceeded since monitoring began in 1969 (monitoring was interrupted for the year 1973). The maximum 1-hour concentration reported during 1977 was 10 ppm which is well below the 30 ppm criterion. Although the annual average was slightly higher during 1977, the value remains very low and the slight increase is not considered a basis for concern. The summary data appear in Table XII, Appendix VI.

A pollution rose for carbon monoxide data obtained for 1977 was constructed utilizing data for wind direction for the 30-metre level of station 14016. The rose, which appears in Figure VI, shows a very slight increase in average concentrations of carbon monoxide associated with southerly and south-southwesterly winds.

OXIDES OF NITROGEN

Oxides of nitrogen are emitted into the atmosphere through combustion processes that oxidize nitrogen to nitric oxide and nitrogen dioxide. Emissions from fossil fueled power generating plants, automobiles, and the petroleum and petrochemical industries comprise the bulk of the man-made sources in Lambton County. However, the influx of nitrogen oxides from sources outside Lambton County contribute appreciably to the levels detected.

The chemiluminescence detection method is utilized to monitor nitrogen oxides at station 14049, located in downtown Sarnia. Oxides of nitrogen are reported separately as nitric oxide, and nitrogen dioxide, and are also combined and reported as nitrogen oxides. Desirable ambient air criteria have not been developed for nitric oxides or nitrogen oxides. The criteria established for nitrogen dioxide are based on odour threshold and protection of human health. Neither the 1-hour criterion of 0.20 ppm nor the 24-hour criterion of 0.10 ppm has been exceeded since monitoring commenced in 1972. Annual average concentrations of nitric oxide, nitrogen dioxide and nitrogen oxides have remained very consistant. Data for oxides of nitrogen appear in Table XIII, Appendix VII.

Due to the combination of heavy traffic patterns and the lineal distribution of power generating plants and industry to the immediate south of station 14049, it is believed that the levels of oxides of nitrogen measured at this location are higher than those that would oocur in most areas of Lambton County. Consequently, the continuous achievement of nitrogen dioxide concentrations lower than the criteria for desirable ambient air at station 14049 indicates that most if not all of Lambton County meets the criteria. The pollution rose for nitrogen dioxide shown in Figure V, Appendix VII illustrates the influx of nitrogen dioxide from emission sources of oxides of nitrogen to the south.

Aside from direct effects that have led to the development of the criteria for nitrogen dioxide, oxides of nitrogen are prime reactants in the photochemical formation

of oxidants. Oxidants are a serious problem in southern Ontario as well as most of the United States. Photochemical oxidants and the significance of oxides of nitrogen are discussed later in this report under Oxidants.

HYDROCARBONS

The most significant man-made source of hydrocarbons is emissions from combustion processes. The automobile, the petroleum and petrochemical industries, and power generating plants account for over 90 per cent of the manman hydrocarbon emissions in the Sarnia area. Nature also contributes a very appreciable portion of the hydrocarbon levels detected in the ambient air. The vast majority of nature's contribution is in the form of methane gas but more complex hydrocarbons such as terpenes from coniferous trees are contributed by nature.

Flame ionization is utilized to detect hydrocarbons at station 14049, located in downtown Sarnia. Total hydrocarbons are expressed in terms of methane. Since the total concentration of hydrocarbons is composed from a mixture of individual hydrocarbons with various characteristics no criteria have been established to represent maximum levels for desirable ambient air quality with respect to total hydrocarbons. Hydrocarbons which are known to create detrimental or annoying effects are controlled through the establishment of standards related to emissions.

The annual average concentrations reported for total hydrocarbons have ranged from 2.3 to 2.8 ppm for 1072 through 1977. The 1977 annual average was 2.4 ppm. A summary of total hydrocarbon data appears in Table XIV, Appendix VIII.

A pollution rose for total hydrocarbons is illustrated in Figure VI, Appendix VIII.

Numerous complex photochemical reactions involving hydrocarbons play an important role in the formation of elevated levels of oxidants in Southern Ontario. This topic is discussed in more detail in the following section.

OXIDANTS

When certain meteorological conditions exist, oxidants may be produced by photochemical reactions involving hydrocarbons and oxides of nitrogen. The association between meteorology and photochemical reactions is very complex and for the purposes of this report it is sufficient to state that warm temperatures and energy from sunlight are critical to the reaction. Consequently, the photochemical formation of oxidants is much more predominant in summer and on warm, sunny spring and fall days. Approximately 90 per cent of the oxidants produced photochemically is in the form of ozone.

The precursor chemicals to ozone (hydrocarbons and oxides of nitrogen) are produced in abundance by man through emissions from combustion processes associated with automobiles, power generating plants and industry. Also, hydrocarbons are emitted to the atmosphere as a result of drying processes and losses from storage facilities. Individual hydrocarbons and groups of hydrocarbons have different photochemical reactivities. Because methane is a very abundant and naturally produced hydrocarbon that does not have a high photochemical reactivity, methane is often segregated from other hydrocarbons in both measurement and terminology.

In addition to man-made sources of precursor chemicals, nature contributes oxides of nitrogen from soil as well as reactive hydrocarbons such as terpenes released from coniferous trees. Also, a minor amount of ozone is produced by lightning.

Ozone is present in the stratosphere where it provides the critical function of absorbing excessive amounts of ultra violet solar radiation that may be biologically harmful. Occasionally, ozone from the stratosphere may be transported downward to cause elevated concentrations of ozone at the earth's surface.

At ground level, ozone and other photochemically formed oxidants such as peroxyacetyl nitrate (PAN) can create adverse affects to human health and vegetation at very low concentrations. The desirable ambient air criterion for ozone is 80 parts per billion (ppb) averaged for a 1-hour period and it was established for protection against these detrimental effects.

The complexity of the photochemical reactions as well as long-range transport of oxidants and precursor chemicals make effective control of oxidants extremely difficult. It is believed that local elevated levels of oxidants can be a result of precursor chemicals and oxidants that have been formed several hundred miles away. Consequently, controlling local sources of hydrocarbon and oxides of nitrogen is not sufficient to eliminate elevated levels of photochemically formed oxidants. It is essential that control strategies for ozone, that are being considered for Ontario, are compatible with strategies being developed by control agencies in the United States.

In the Sarnia area ozone has been monitored at station 14049 located in downtown Sarnia, since 1974. In February, 1977 ozone monitoring commenced at station 14118, which is located at a water pumping station operated by the Petrolia Public Utilities Commission in a rural location approximately 7 miles east of Sarnia. This latter station provides information on ozone levels in the rural community where vegetation damage would be most critical. The monitoring instruments continuously record ozone levels using the chemiluminescence technique. .

From 1974 through 1977 there is no apparent trend in the frequency excursions above the 1-hour criterion for ozone. The strong dependency of photochemical reactions on meteorology and the variability of meteorology from year to year makes it extremely difficult to distinguish a trend in ozone levels.

During 1977 there were more frequent excursions above the 1-hour criterion recorded at the rural monitoring site (station 14118) than at the urban site (station 14049). Since oxidants react with other pollutants and there are lower levels of other pollutants at the rural location, fewer oxidants are consumed by reactions with the other pollutants in rural areas.

There is also no discernible trend in the maximum value of ozone recorded at station 14049. Again the dependency of photochemical reactions on meteorology makes the distinguishing of trends most difficult. The maximum ozone concentration recorded at station 14049 during 1977 was slightly higher than the maximum value recorded at station 14118. A summary of ozone data appears in Table XV, Appendix IX.

A pollution rose based on data obtained for ozone during 1977 at station 14049 and wind direction data from the 30-metre level at station 14016 appears in Figure VII, Appendix IX. This pollution rose reveals a pattern of fluctuating average concentrations of ozone with wind direction. This is not surprising since higher concentrations, which tend to occur in the warm months, will be dampened by lower concentrations that occur in the cooler months. However, a different type of pollution rose was constructed to represent the relationship between the wind direction data obtained from the 30-metre level at station 14016 and the percentage of the total number of ozone values above the 1-hour criterion reported for both stations

14049 and 14118. These roses, which appear in Figure VIII, Appendix IX, show that most excursions above the criterion occur when winds are southerly to southwesterly. Since winds from these directions would be unlikely to blow emissions from the industries immediately south of Sarnia towards station 14118 and since automobile emissions in the general Sarnia area would also not tend to be high in southerly to southwesterly directions from this station, it is apparent that long range transport of ozone and/or its precursor chemicals contribute significantly to excursions above the 1-hour criterion for ozone.

Phytotoxicology surveys, conducted on an annual basis in Southern Ontario, have revealed damage to vegetation attributable to ozone each year. The survey conducted in 1977 proved to be no exception as ozone damage was noted over much of the study area. In addition to the concentration of ozone and the exposure period, the degree of damage to vegetation is dependent on other factors such as type and age of vegetation, soil conditions, and meteorological conditions.

FLUORIDATION RATE

In the Sarnia area fluorides are emitted into the atmosphere from fossil-fueled power plants where it is encountered as an impurity in coal, from a fertilizer plant where it occurs as a constituent in phosphate rock, and from petroleum refineries where it is used as a catalyst in alkylation.

Fluorides are monitored by exposing 100 square centimetres (cm^2) of limed filter paper for 30-days. The amount of fluoride that has reacted with the filter paper is analysed in the laboratory and the resulting concentration is referred to as the fluoridation rate. The desirable ambient air criteria for fluoridation rate are based on damage to vegetation. Consequently, there is a criterion of 40 micrograms (ug) of fluoride per 100 cm^2 per 30 days for the growing season (April 15 to October 15) and a less restrictive criterion of 80 ug F/100 cm^2/30 days for the period of October 16 to April 14. Since the months of April and October are included in both criteria, excursions during these months are determined by comparing the fluoridation rate to the average of the two criteria (60 ugF/100 cm^2/30 days).

Fluoridation rate is monitored at station 14049, located in downtown Sarnia, and station 14004, located south of Courtright in the vicinity of the fertilizer plant of Canadian Industries Limited and power plants operated by Detroit Edison and Ontario Hydro.

At station 14049 the frequency of excursions above the desirable ambient air criteria and the annual average fluoridation rate were lower from 1975 through 1977 than from 1972 through 1974. The infrequent excursions in recent years have been only marginally above the criteria. Phyto-toxicology studies have revealed no injury to vegetation in Sarnia attributable to fluoride.

In the Courtright area the Ministry started monitoring fluoridation rate in June 1976. Consequently, there are limited Ministry data available to distinguish any trend in fluoridation rates. However, the number of excursions and the magnitude of the fluoridation rates recorded for station 14004 indicates levels of fluoridation rate above background. Although phytotoxicology studies are not very effective in detecting trends in fluoride levels, vegetation damage has been detected in the area for a number of years and in 1977 damage was more severe than usual. The predominant source of the fluorides contributing to the vegetation damage was Canadian Industries Limited. Canadian Industries Limited has conducted fluoridation rate surveys since the mid 1960's.

Fluoridation rate data for stations 14004 and 14049 appear in Table XVI, Appendix X.

DISCUSSION

The data provided by the Ministry of the Environment's monitoring program since 1972 reveal improvements in ambient air levels of suspended particulates, sulphur dioxide, combined hydrogen sulphide and mercaptans, and in downtown Sarnia, fluoridation rate. Levels of carbon monoxide, oxides of nitrogen and hydrocarbons have been consistent and there have been no excursions of desirable ambient air quality criteria pertaining to these pollutants.

Concentrations of ozone have fluctuated such that no trend in levels can be detected. However, the desirable ambient air quality criterion for ozone has been exceeded fairly frequently and vegetation damage attributable to ozone has been detected annually.

The improvement in levels of sulphur dioxide was most evident in 1977 by the large decrease in the frequency of excursions of the 1-hour criterion at station 14004 and 14016 and the 24-hour criterion at station 14004. These improvements are attributed mainly to increased dispersion and better control of sulphur dioxide emissions from Detroit Edison's St. Clair Power Generating Station.

Levels of sulphur dixoide in the downtown area of Sarnia have demonstrated an improvement since 1972 but satisfactory conditions have not yet been achieved. A new control strategy for sulphur dioxide emissions is being developed for sources in the area and it is anticipated that future levels of sulphur dioxide will reflect the additional controls.

Although ozone levels are unsatisfactory and result in vegetation damage, achievement of acceptable levels will depend on control strategies being considered by Ontario and control agencies in the United States. Long range transport of ozone and its precursor chemicals contribute significantly to local levels of ozone. The frequency of elevated levels of ozone is greater in rural areas where other pollutants are less abundant and therefore less likely to react with ozone to reduce its concentration. It is in the rural area that the economic impact of ozone damage to agricultural crops is more severe.

Above-background levels for fluoridation rate were noted in the vicinity of the fertilizer plant of Canadian Industries Limited and localized vegetation damage has been attributed to fluoride emissions from that operation. It is recommended that the Company and the Industrial Abatement Section of the Ministry of the Environment investigate means of reducing the effects of these emissions.

The routine ambient air monitoring program does not address odours with the exception that the desirable ambient air criteria for nitrogen dioxide, hydrogen sulphide, and mercaptans are based on odour detection levels. Due to the subjective nature of odours and the vast number of chemicals that may create offensive odours it is not practical to attempt to routinely monitor for odours. Complaints concerning odour are investigated by Ministry staff and corrective action is dependent on the specific situation.

The routine ambient air monitoring program does not measure chemicals such as vinyl chloride and mercury which require specialized detection capabilities. This type of pollution is monitored during short-term specialized studies.

APPENDIX I

DESCRIPTION OF

MONITORING NETWORK

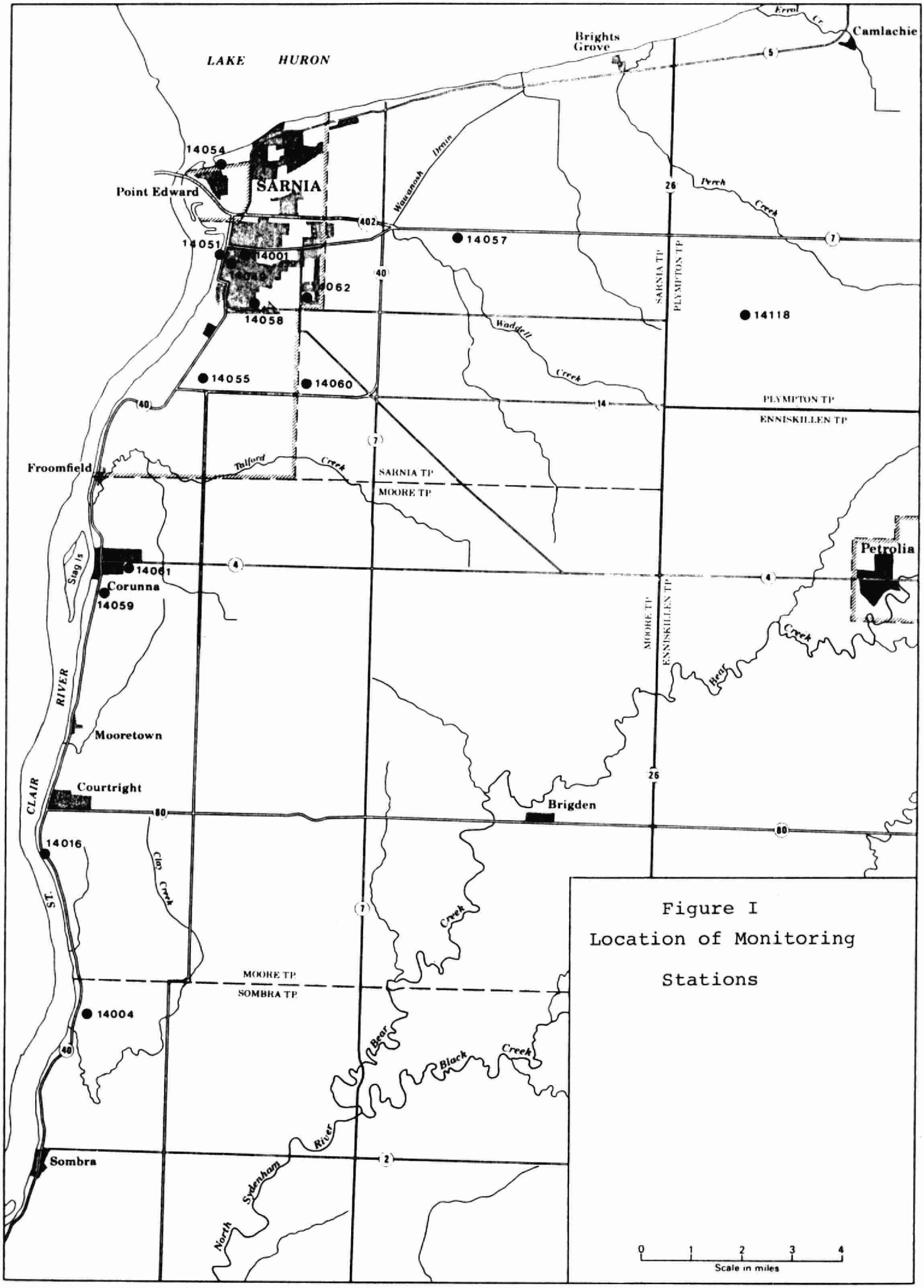


Figure I
Location of Monitoring Stations

TABLE 1 - LOCATION OF MONITORING STATIONS
AND POLLUTANTS MONITORED

STATION NO.	LOCATION	PARAMETERS MEASURED	HEIGHT OF MEASUREMENTS	PURPOSE OF STATION & COMMENTS
14001	Sarnia General Hospital	Suspended Particulates	16 m.	Historical station which has been in operation since 1962. Does not reflect ground level concentrations but does indicate more direct effects of particulates from high stacks.
14004	5 1/2 miles south of Courtright	Continuous SO_2, Fluoridation Rate.	4 m.	Monitors SO_2 from power generating stations and fluorides from fertilizer industry.
14016	1 1/4 miles south of Courtright	Suspended Particulates Continuous SO_2 Sulphation Rate WS, WD, Temp., WS, WD, Δ Temp., WS, WD, Δ Temp., Telemetering Equipment	1 m. 4 m. 4 m. 10 m. 30 m. 92 m.	Monitors suspended particualtes and sulphur dioxides in relation to power generating plants. Provides meteorological data required for stability forecasts and air quality interpretations.
14049	Victoria St. Downtown Sarnia	Continuous SO_2, CO, NO, NO_2, NO_x, O_3, H_2S & Mercaptans, Total Hydrocarbons, 2-HR. COH, 1-HR. COH, Suspended Particulates, Dustfall Fluoridation Rate, Sulphation Rate. Telemetering Equipment.	4 m.	Monitors main air pollutants in a heavily populated areas where the pollutants from traffic, commercial establishments, and the heavily industrialized complex south of the monitoring station should be high relative to residential areas. Provides Air Pollution Index for Sarnia.

TABLE 1 - continued

STATION NO.	LOCATION	PARAMETERS MEASURED	HEIGHT OF MEASUREMENTS	PURPOSE OF STATION & COMMENTS
14051	Front & Lochiel St., Downtown Sarnia	Sulphation Rate, Suspended Particulates, Dustfall	3 m.	Monitors pollutants in commercial area which is also affected by heavily industrialized area to south. Since this is the location of a monitoring station operated by the Lambton Industrial Society, cross checking of monitoring techniques is possible.
14054	Sarnia Yacht Club	Sulphation Rate Suspended Particulates	5 m.	Monitors suspended particulates and relative amounts of sulphur oxides in the north Sarnia-Point Edward area.
14055	Churchill Road and Tashmoo St.	Sulphation Rate	4 m.	Monitors relative amounts of sulphur dioxide in the Sarnia industrial complex.
14057	Briarwood Recreation Centre	Sulphation Rate, Suspended Particulates	10 m.	Monitors suspended particulates and relative amounts of sulphur oxides in Sarnia Township, northeast of the main industrial area.
14058	Tecumseh Park Sarnia	Sulphation Rate	4 m.	Monitors relative amount of sulphur dioxide in south residential Sarnia, close to the industrial area.

TABLE 1 - continued

STATION NO.	LOCATION	PARAMETERS MEASURED	HEIGHT OF MEASUREMENTS	PURPOSE OF STATION & COMMENTS
14059	Riverbend, Corunna	Sulphation Rate Suspended Particulates	4 m.	Monitors suspended particulates and relative amounts of sulphur oxides in the residential area of Corunna which is surrounded by industry and generating stations.
14060	MacGregor St. & Hwy. 40, Sarnia	Sulphation Rate	4 m.	Monitors relative amount of sulphur oxide in southeast Sarnia.
14061	Colborne and Fane St., Corunna	Sulphation Rate	4 m.	Monitors relative amount of sulphur oxide in a residential area of Corrunna.
14062	Eastland Plaza, 242A Indian Rd. S., Sarnia	Continuous SO_2 Sulphation Rate WS, WD	6 m. 10 m.	Monitors SO_2 in residential-commercial area at east Sarnia. Provides meteorological data useful in identifying sources of SO_2.
14118	Petrolia Public Utilities Commission Pumping Station 4 miles west of Wyoming.	O_3	5 m.	Monitors ozone levels in a rural location.

TABLE II - DESIRABLE AMBIENT AIR QUALITY CRITERIA
ESTABLISHED FOR ONTARIO

PARAMETER	DESIRABLE AMBIENT AIR QUALITY CRITERIA	PRIME REASONS FOR ESTABLISHING CRITERIA OR MONITORING PARAMETER
Carbon Monoxide	30 ppm averaged for 1-hour	Protection of human health
	13 ppm averaged for 8-hours	Protection of human health
Dustfall	7.0 gm/metre^2 in 30-days	Historical and in keeping with other control agencies.
	4.5 gm/metre^2 (monthly average in 1 year)	
Fluoridation Rate	40 ug F/100 cm^2 of limed filter paper in 30-days during April 15 to October 15	Protection of vegetation.
	80 ug F/100 cm^2 of limed filter paper in 30-days during October 16 to April 14.	Protection of vegetation (less restrictive criterion during the non growing season).
Hydrocarbons (Total)	NONE	Effects of hydrocarbons vary widely depending on their chemical-physical nature.

TABLE II - continued

PARAMETER	DESIRABLE AMBIENT AIR QUALITY CRITERIA	PRIME REASONS FOR ESTABLISHING CRITERIA OR MONITORING PARAMETER
Hydrogen Sulphide	0.02 ppm averaged for 1-hour	Protection against offensive odours.
Mercaptans	0.01 ppm averaged for 1-hour	Protection against offensive odours.
Nitric Oxide	NONE	Reacts with oxygen to produce NO_2.
Nitrogen Dioxide	0.02 ppm averaged for 1-hour	Protection of human health and protection against offensive odours.
	0.10 ppm averaged for 24-hours	Protection of human health and protection against offensive odours.
Nitrogen Oxides	NONE	
Ozone	0.08 ppm averaged for 1-hour	Protection of vegetation, adverse health effects.
Soiling (Coefficient of Haze - COH)	1.0 COH per 1000 ft. of air averaged for 24-hours	Based on health effects in combination with SO_2.
	0.5 COH per 1000 ft. of air averaged for 1-year	Based on health effects in combination with SO_2.

TABLE II - continued

PARAMETER	DESIRABLE AMBIENT AIR QUALITY CRITERIA	PRIME REASONS FOR ESTABLISHING CRITERIA OR MONITORING PARAMETER
Sulphation	0.7 mg of SO_3 per 100 cm^2 of lead peroxide per day based on 30 days of exposure	Serves to measure relative amounts of sulphur oxides over extended periods of time thus permitting comparisions to annual average SO_2 concentrations.
Sulphur Dioxide	0.25 ppm averaged for 1-hour	Protection of vegetation.
	0.10 ppm averaged for 1-day (24 hours)	Protection of human health.
	0.02 ppm averaged for 1-year	Protection of vegetation.
Suspended Particulates	120 ug/m^3 averaged for 24-hours	Based on impairment of visibility.
	A geometric mean of 60 ug/m^3 during 1 year.	Based on public awareness of visibile pollution.
Cadmium in Suspended Particulates	2.0 ug/m^3 averaged for 24-hours	Protection of human health.
Lead in Suspended Particulates	5 ug/m^3 averaged for 24-hours	Protection of human health.
	A geometric mean of 2 ug/m^3 over a 30-day period.	Protection of human health.
Nickel in Suspended Particulates	2.0 ug/m^3 averaged for 24-hours	Protection of vegetation.
Vanadium in Suspended Particulates	2.0 ug/m^3 averaged for 24-hours	Protection of human health.

APPENDIX II

METEOROLOGICAL DATA

TABLE III - AVERAGE FREQUENCY OF WIND DIRECTION
AT THE 30-METRE LEVEL OF STATION 14016

YEAR	PERCENT FREQUENCY OF WIND DIRECTION							
	N	NE	E	SE	S	SW	W	NW
1977	11.3	9.8	5.3	7.2	18.5	21.2	14.1	12.6
1976	12.2	9.2	3.5	4.7	18.1	20.5	15.1	16.7
1975	11.5	11.2	7.3	7.5	18.6	18.3	11.7	13.8
1974	Data Unavailable							
1973	Data Unavailable							
1972	15.8	12.0	6.5	8.3	17.4	16.4	11.7	12.0

APPENDIX III

PARTICULATES

TABLE IV: CONCENTRATIONS OF DUSTFALL (GRAMS/SQUARE METRE /30 DAYS) IN DOWNTOWN SARNIA

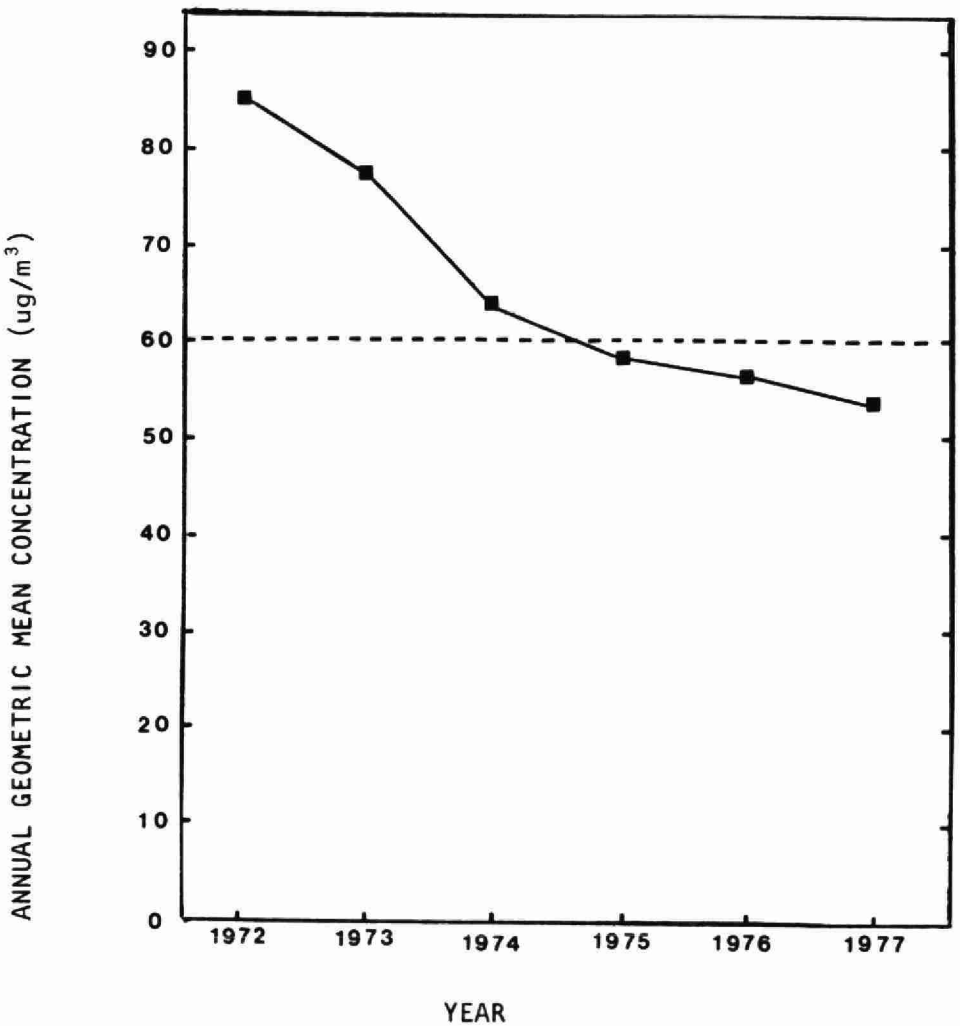
YEAR	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	ANNUAL ARITHMETIC MEAN
STATION 14049													
1972	*	7.4	7.7	7.0	2.1	*	2.5	3.2	2.1	4.2	*	3.2	4.4
1973	5.3	3.5	10.5	4.6	7.7	4.6	3.9	2.8	3.5	6.0	8.8	3.5	5.4
1974	3.5	4.6	9.8	5.6	5.6	6.0	4.2	2.5	3.2	3.5	4.2	3.9	4.7
1975	4.2	4.2	6.0	6.0	6.0	4.6	3.2	6.7	4.2	5.6	3.9	2.8	4.8
1976	2.8	6.0	8.1	6.7	5.6	4.9	4.9	3.2	3.5	4.6	4.3	4.2	4.9
1977	1.6	5.9	8.7	5.4	5.0	5.5	2.6	3.0	4.4	3.3	5.6	5.5	4.7
STATION 14051													
1972	*	*	*	7.4	*	*	2.1	6.7	4.9	3.9	*	3.2	4.7
1973	3.5	2.5	6.3	5.6	6.3	6.3	1.8	2.5	2.8	4.9	5.6	2.8	4.2
1974	3.2	4.9	7.0	7.0	5.6	7.0	4.9	2.8	4.2	4.6	3.2	4.2	4.9
1975	4.6	2.1	4.2	2.1	5.6	5.3	4.2	9.1	3.5	5.6	4.2	2.1	4.4
1976	3.2	4.9	6.7	5.3	4.9	4.6	3.5	3.2	2.8	3.2	2.8	2.8	4.0
1977	0.9	3.9	5.6	5.5	4.9	5.2	4.6	4.0	5.1	3.1	4.4	4.4	4.3

Underlined Values Exceed Either the Criterion of 7.0 gm/m^2/30 days or the Annual Criterion of an Average of 4.5 gm/m^2/30 days.

TABLE V - SUMMARY OF DATA FOR SUSPENDED PARTICULATES
1972 to 1977

STATION NUMBER	1977 ANNUAL GEOMETRIC MEAN ug/m^3	1977 PERCENTAGE OF VALUES GREATER THAN 24 - HOUR CRITERION	1976 ANNUAL GEOMETRIC MEAN ug/m^3	1976 PERCENTAGE OF VALUES GREATER THAN 24- HOUR CRITERION	1975 ANNUAL GEOMETRIC MEAN ug/m^3	1975 PERCENTAGE OF VALUES GREATER THAN 24 - HOUR CRITERION	1974 ANNUAL GEOMETRIC MEAN ug/m^3	1974 PERCENTAGE OF VALUES GREATER THAN 24 - HOUR CRITERION	1973 ANNUAL GEOMETRIC MEAN ug/m^3	1973 PERCENTAGE OF VALUES GREATER THAN 24 - HOUR CRITERION	1972 ANNUAL GEOMETRIC MEAN ug/m^3	1972 PERCENTAGE OF VALUES GREATER THAN 24 - HOUR CRITERION
14001	59	15	59	10	55	4	54	4	68	19	79	16
14016	46	0	48	2	48	2	50	5	61	17	67	10
14049	76	26	73	20	71	12	82	23	101	42	103	36
14051	53	9	57	9	61	9	80	23	91	36	88	33
14053	RELOCATED AT NEARBY 14057				52	8	55	14	61	17	71	15
14054	49	4	56	12	60	13	74	21	82	29	113	40
14057	46	0	59	13								
14059	50	0	40	0								
14061	RELOCATED AT NEARBY 14059				59	8	56	5	78	19	75	24
AVERAGE FOR ALL STATIONS	54	8	56	9	58	8	64	14	77	26	85	25

Figure II - Trend in Levels of Suspended Particulate
Based on Data from Seven Monitoring Stations
Per Year in The Sarnia Area: 1972 to 1977.



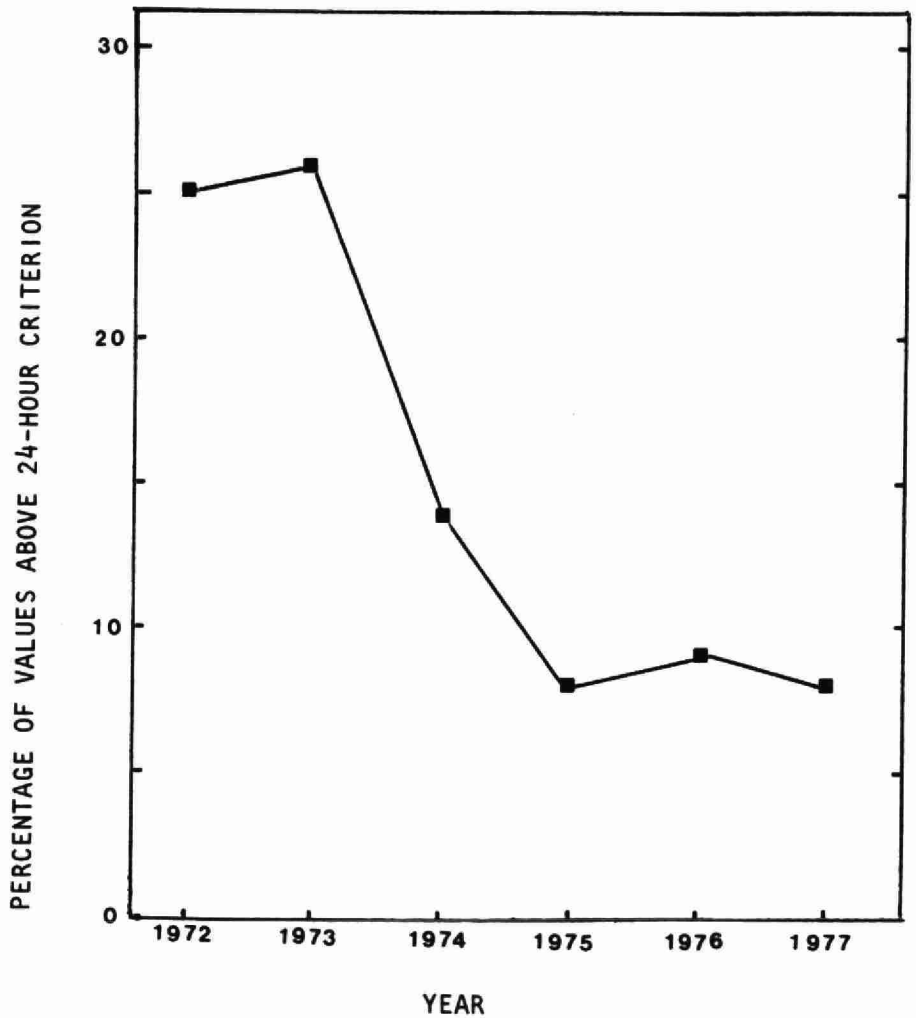


TABLE VI - SUMMARY OF VARIOUS CONSTITUENTS OF SUSPENDED PARTICULATES: 1971 to 1977.
(ug/m^3)

STATION AND YEAR	CADMIUM # of Samples	CADMIUM Concentrations Average	CADMIUM Concentrations Max.[m]	CHROMIUM # of Samples	CHROMIUM Concentrations Average	CHROMIUM Concentrations Max.[m]	COPPER # of Samples	COPPER Concentrations Average	COPPER Concentrations Max.[m]	IRON # of Samples	IRON Concentrations Average	IRON Concentrations Max.[m]	LEAD # of Samples	LEAD Concentrations Average	LEAD Concentrations Max.[m]
14001															
1971	21	0.003	0.014	21	0.010	0.033	21	0.21	2.21	18	1.8	4.0	19	0.5	1.1
1976	10	0.001	0.004	10	0.017	0.066	10	0.31	0.73	10	1.0	2.4	10	0.3	0.6
1977	18	0.000	0.003	18	0.009	0.030	18	0.68	2.48	18	1.2	5.8	18	0.3	1.3
14016															
1971	46	0.005	0.027	46	0.018	0.058	46	0.05	0.17	37	2.3	4.9	31	0.4	0.8
1976	18	0.000	0.003	18	0.003	0.011	18	0.41	1.17	18	0.6	1.6	18	0.2	0.4
1977	21	0.000	0.002	21	0.008	0.025	21	0.31	0.58	21	0.6	1.8	21	0.2	0.6
14049															
1971	66	0.013	0.342	66	0.014	0.038	66	0.28	2.23	60	2.1	8.9	60	0.9	2.8
1972	63	0.007	0.055	4	0	0	63	0.17	0.48				63	0.8	1.9
1973	89	0.010	0.075				89	0.18	0.70				93	1.0	2.7
1974													64	1.0	3.2
1975	17	0	0.005										74	0.6	1.7
1976													70	0.5	1.5
1977													50	0.6	1.3
14051															
1971	21	0.005	0.015	21	0.012	0.032	21	0.21	0.90	18	1.5	3.0	18	0.5	1.1
1976	17	0.001	0.003	18	0.032	0.157	17	0.08	0.15	17	1.0	3.4	17	0.3	0.8
1977	20	0.001	0.003	20	0.007	0.021	20	0.10	0.28	20	0.6	1.3	20	0.2	0.5
14053															
1971	23	0.004	0.010	23	0.010	0.034	23	0.07	0.13	19	1.3	2.8	21	0.3	1.0
1972	53	0.002	0.009	57	0.002	0.019	53	0.10	0.50	53	1.7	7.7	53	0.3	0.9
1973	52	0.004	0.019	47	0.007	0.025	52	0.18	0.48	47	1.3	3.6	52	0.4	1.8
14054															
1971	19	0.006	0.013	19	0.013	0.034	19	0.05	0.19	19	2.1	7.5	19	0.7	1.4
1976	3	0.002	0.004	3	0	0	3	0.17	0.18	3	0.5	0.7	3	0.2	0.3
1977	15	0.001	0.003	15	0.003	0.010	15	0.46	2.16	15	0.7	1.9	15	0.2	0.5
CRITERION FOR DESIRABLE AMBIENT AIR		2.0 ug/m^3/24 hrs.													5.0 ug/m^3/24 hrs.

Table VI - Continued (ug/m^3)

STATION AND YEAR	MANGANESE # of Samples	MANGANESE Concentrations Average	MANGANESE Concentrations Max.^{m}	NICKEL # of Samples	NICKEL Concentrations Average	NICKEL Concentrations Max.^{m}	NITRATES # of Samples	NITRATES Concentrations Average	NITRATES Concentrations Max.^{m}	SULPHATES # of Samples	SULPHATES Concentrations Average	SULPHATES Concentrations Max.^{m}	VANADIUM # of Samples	VANADIUM Concentrations Average	VANADIUM Concentrations Max.^{m}	ZINC # of Samples	ZINC Concentrations Average	ZINC Concentrations Max.^{m}
14001																		
1971	21	0.06	0.21	21	0.053	0.089	18	4.4	14.0	18	12.7	31.4	21	0.02	0.06	18	0.3	2.3
1976	2	0.30	0.37	10	0.029	0.107	58	3.8	15.8	58	8.6	44.6	10	0.02	0.11	10	0.1	0.4
1977	18	0.04	0.23	18	0.014	0.064	47	4.7	24.5	48	12.9	43.9	18	0.01	0.07	15	0.7	1.3
14016																		
1971	44	0.05	0.14	46	0.026	0.085	31	3.6	11.6	31	12.0	27.5	44	0.01	0.10	37	0.1	0.5
1976	8	0.01	0.04	18	0.013	0.031	96	4.0	20.0	105	8.7	33.4	18	0.00	0.02	18	0.1	0.4
1977	21	0.03	0.09	21	0.022	0.165	54	3.7	27.8	54	10.0	24.6	21	0.01	0.08	18	0.3	4.8
14049																		
1971	60	0.05	0.27	66	0.031	0.106	60	4.2	12.0	60	10.9	30.7	60	0.02	0.10	60	0.2	3.3
1972				63	0.031	0.162							63	0.03	0.29			
1973				87	0.029	0.260							89	0.04	0.56			
1975	7	0.04	0.08							3	11.4	19.1	7	0.01	0.03			
1976							6	2.9	7.1									
1977																		
14051																		
1971	15	0.07	0.21	21	0.039	0.085	19	4.0	11.2	19	12.9	25.7	15	0.03	0.10	19	0.4	2.3
1976	17	0.03	0.07	17	0.023	0.084	59	3.7	11.7	58	9.3	45.1	17	0.03	0.12	17	0.2	1.2
1977	20	0.03	0.06	20	0.009	0.022	56	3.9	22.4	56	10.9	32.1	20	0.00	0.02	17	0.7	1.3
14053																		
1971	17	0.05	0.19	23	0.030	0.082	18	3.6	8.5	18	9.4	25.0	17	0.01	0.03	19	0.1	0.4
1972	53	0.04	0.23	52	0.017	0.085							53	0.01	0.04	53	0.1	0.8
1973	47	0.05	0.20	52	0.049	0.180							52	0.02	0.17	47	0.2	0.9
14054																		
1971	19	0.07	0.19	19	0.030	0.090	17	4.6	9.0	17	11.7	21.8	19	0.03	0.10	19	0.3	1.6
1976	3	0.02	0.04	3	0.023	0.063	54	3.7	13.2	61	8.9	34.8	3	0.02	0.03	3	0.2	0.3
1977	15	0.03	0.10	15	0.009	0.021	50	3.8	20.2	50	9.9	25.7	15	0.01	0.03			
CRITERION FOR DESIRABLE AMBIENT AIR				2.0 ug/m^3/24 hrs.									2.0 ug/m^3/24 hrs.					

TABLE VII - SUMMARY OF DATA FOR SOILING INDEX:
1972 to 1977

PARAMETER / YEAR	1977	1976	1975	1974	1973	1972
Annual Average*	0.3	0.3	0.3	0.3	0.3	0.4
Soiling Index (COH/1000 ft. of air)						
Percentage of Values Above the Criterion Established for 24-hours 1.0 COH/1000 ft. of Air	0	0.6	0	0.3	0	0

* Criterion for Annual Average is 0.5 COH/1000 ft. of Air.

APPENDIX IV

SULPHUR OXIDES

TABLE VIII - SUMMARY OF DATA FOR SULPHUR DIOXIDE:
1972 to 1977.

STATION NUMBER	YEAR	ANNUAL AVERAGE (ppm)	PERCENTAGE OF VALUES GREATER THAN 1-HOUR CRITERION	PERCENTAGE OF VALUES GREATER THAN 24-HOUR CRITERION
14004	1977	0.01	0.03	0.0
	1976	0.01	0.58	1.3
	1975	0.01	0.36	0.7
14016	1977	0.02	0.00	0.0
	1976	0.02	0.06	0.0
	1975	0.02	0.07	0.0
	1974	0.02	0.14	0.0
	1973	0.01	0.05	0.0
14049	1977	0.02	0.06	0.8
	1976	0.02	0.07	0.9
	1975	0.02	0.07	0.9
	1974	0.03	0.44	1.2
	1973	0.02	0.17	0.3
	1972	0.02	0.37	2.1
14062	1977	- COMMENCED OPERATION OCTOBER 13, 1977. NO VALUES RECORDED ABOVE CRITERIA		

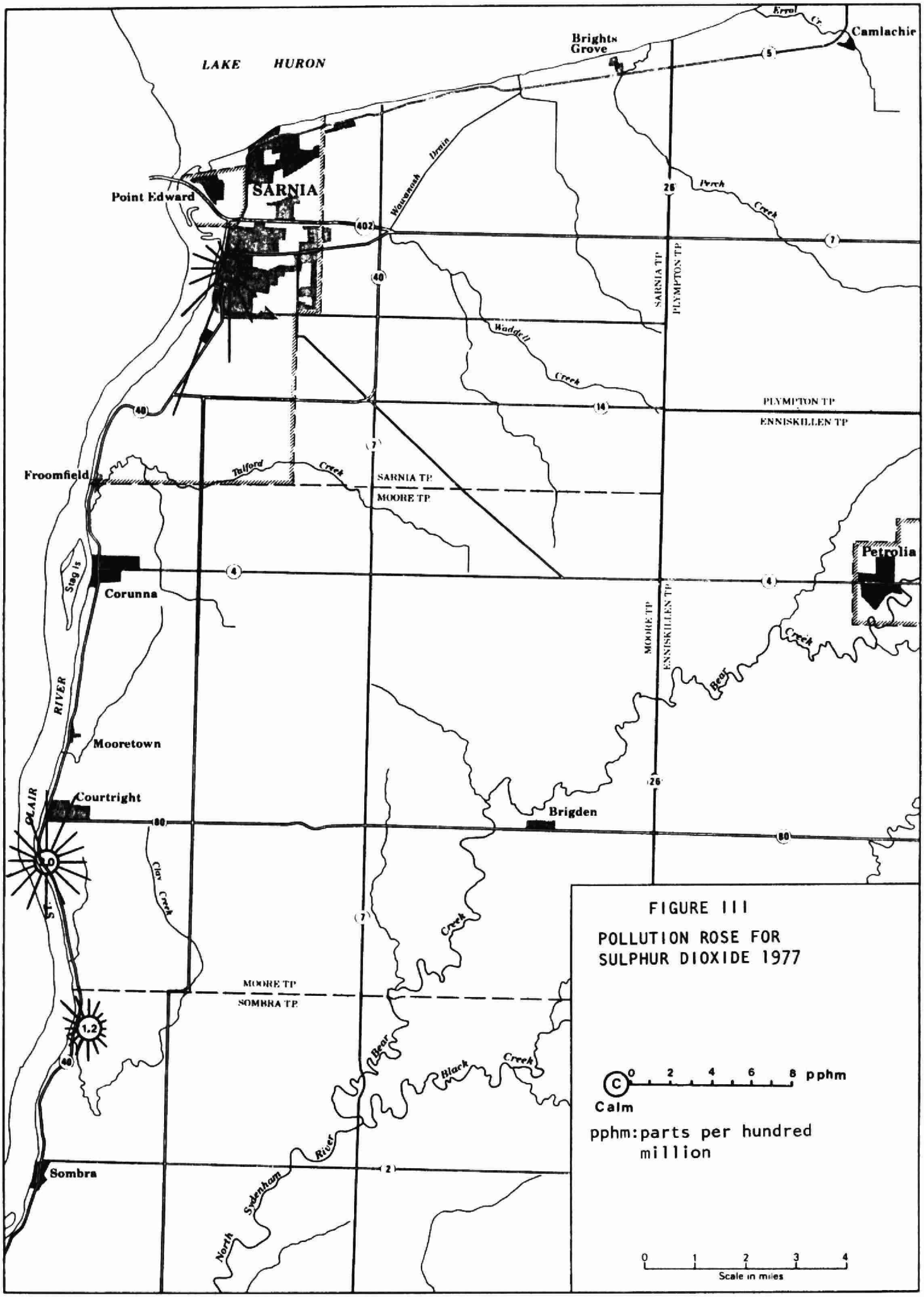

LAKE HURON
Brights Grove
Errol Cr.
Camlachie
SARNIA
Point Edward
Wawanosh Drain
Perch Creek
SARNIA TP
PLYMPTON TP
Waddell Creek
PLYMPTON TP
ENNISKILLEN TP
Talford Creek
SARNIA TP
MOORE TP
Froomfield
Petrolia
Corunna
Stag Is
MOORE TP
ENNISKILLEN TP
Bear Creek
St. CLAIR RIVER
Mooretown
Courtright
Brigden
Clay Creek
Creek
MOORE TP
SOMBRA TP
Bear Creek
Black Creek
Sombra
North Sydenham River
FIGURE III
POLLUTION ROSE FOR SULPHUR DIOXIDE 1977
C
0 2 4 6 8 pphm
Calm
pphm: parts per hundred million
0 1 2 3 4
Scale in miles

TABLE IX - SULPHATION RATES - 1977

SULPHATION RATES (MG. SO_3/100 CM^2/DAY)- 1977													
STATION	JANUARY	FEBRUARY	MARCH	ARPIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	ANNUAL AVERAGE
14016	*	0.58	0.67	0.87	0.71	*	0.46	0.45	0.37	0.43	0.49	0.59	0.56
14049	1.54	1.18	1.17	1.00	1.09	0.87	0.78	1.04	*	0.97	0.90	1.45	1.09
14051	1.64	1.39	1.24	0.95	1.03	0.99	0.84	1.23	0.68	0.78	1.04	1.60	1.08
14054	1.02	0.82	0.67	0.63	0.65	0.57	0.46	0.55	0.38	0.65	0.63	0.89	0.66
14055	1.70	1.39	1.66	1.16	1.31	STATION TERMINATED							**
14057	0.75	0.72	0.49	0.43	0.47	0.40	0.31	0.41	0.25	0.38	0.40	0.65	0.47
14058	1.05	0.72	0.41	0.57	0.51	*	0.46	0.41	0.30	0.45	0.58	0.96	0.58
14059	0.73	0.55	0.61	0.96	0.73	1.14	0.53	0.64	0.37	0.62	0.42	0.62	0.66
14060	1.49	0.89	0.83	1.05	0.93	.58	0.38	0.46	0.38	0.52	0.50	0.62	0.72
14061	0.93	0.60	0.77	*	0.66	1.05	0.59	0.68	0.63	0.66	0.52	0.74	0.71
14062	*	*	*	*	*	*	0.50	0.58	0.49	0.52	*	*	**

* Data Unavailable
** Insufficient Data to Compute Representative Annual Average

Underlined values exceed criterion for desirable ambient air quality (0.7 mg/ SO_3/100 CM^2/Day).

TABLE X - SUMMARY OF SULPHATION RATES: 1972 to 1977

		DATA RELATED TO STATION NUMBERS											
		14016	14049	14051	14053	14054	14055	14057	14058	14059	14060	14061	14062
1977	ANNUAL AVERAGE	0.56	1.09	1.12	*	0.66	**	0.47	0.59	0.66	0.72	0.71	**
	PERCENTAGE OF VALUES GREATER THAN CRITERION	20	100	92		25		17	27	33	42	36	
1976	ANNUAL AVERAGE	0.45	0.76	0.93	0.32	0.59	1.07	0.33	0.48	0.44	0.50	0.53	
	PERCENTAGE OF VALUES GREATER THAN CRITERION	8	33	58	0	42	75	0	18	0	25	25	
1975	ANNUAL AVERAGE	0.57	0.81	0.91	0.34	0.54	0.98		0.61		0.56	0.60	
	PERCENTAGE OF VALUES GREATER THAN CRITERION	25	58	75	0	17	75		29		17	25	
1974	ANNUAL AVERAGE	0.67	0.91	1.26	0.47	0.69	0.97		0.71		0.67	0.67	
	PERCENTAGE OF VALUES GREATER THAN CRITERION	27	82	91	9	60	60		45		45	40	
1973	ANNUAL AVERAGE	0.60	0.94	1.04	0.42	0.60	1.05		0.62		0.69	0.70	
	PERCENTAGE OF VALUES GREATER THAN CRITERION	25	75	92	0	25	100		42		50	50	
1972	ANNUAL AVERAGE	0.86	1.02	1.11	0.47	0.66	1.21		0.69		0.70	0.87	
	PERCENTAGE OF VALUES GREATER THAN CRITERION	67	83	75	8	18	92		33		33	83	

* - Terminated
** - Insufficient Data

APPENDIX V

HYDROGEN SULPHIDE AND MERCAPTANS

TABLE XI: SUMMARY OF DATA FOR HYDROGEN SULPHIDE AND MERCAPTANS

AT STATION 14049: 1974 to 1977.

PARAMETER / YEAR	1977	1976	1975	1974
Annual Average (PPM)	0.001	0.001	0.001	0.007
Percentage of Values Above the Criterion Established for 1-Hour (0.02 ppm)	0.01	0.04	0.38	9.78

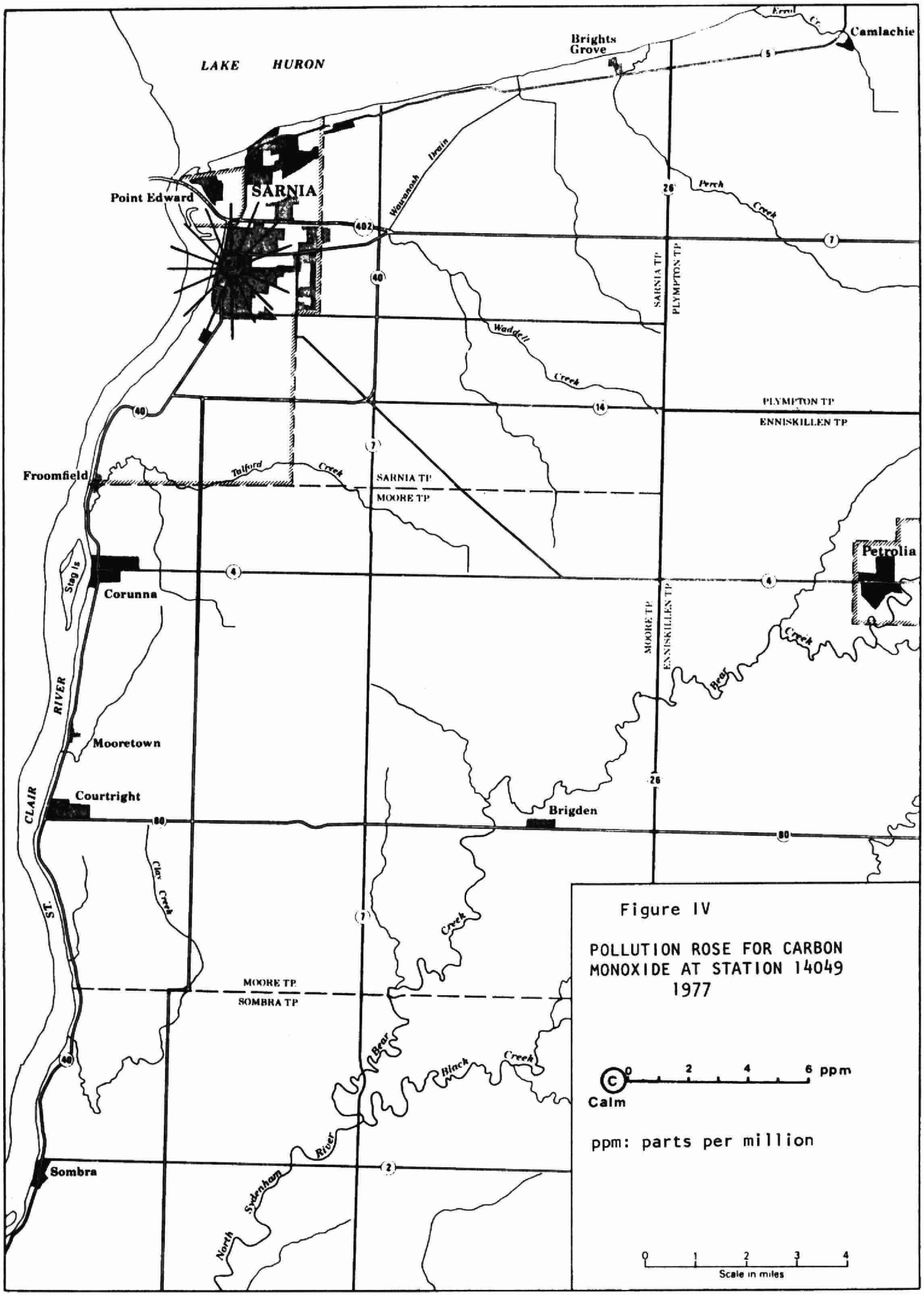
NOTE: Annual Average Concentrations are the Combined Total of Hydrogen Sulphide and Mercaptans. 1-Hour Criterion is for Hydrogen Sulphide But Excursions are Determined Using Combined Concentrations of Hydrogen Sulphide and Mercaptans.

APPENDIX VI

CARBON MONOXIDE

TABLE XII: SUMMARY OF DATA FOR CARBON MONOXIDE AT STATION 14049
1972 to 1977

PARAMETER \ YEAR	1977	1976	1975	1974	1973	1972
Annual Average (PPM)	2	1	1	1	NO DATA	3
Percentage of Values Above the Criterion Established for: 1-Hour	0	0	0	0		0
8 Consecutive Hours	0	0	0	0		0


LAKE HURON
Brights Grove
Camlachie
SARNIA
Point Edward
Waubuno Drain
Perch Creek
SARNIA TP
PLYMPTON TP
Waddell Creek
PLYMPTON TP
ENNISKILLEN TP
Froomfield
Talford Creek
SARNIA TP
MOORE TP
Petrolia
Stag Is
Corunna
MOORE TP
ENNISKILLEN TP
Bear Creek
CLAIR RIVER ST.
Mooretown
Courtright
Brigden
Clay Creek
Creek
MOORE TP
SOMBRA TP
Bear Creek
Black Creek
Sombra
North Sydenham River
Figure IV
POLLUTION ROSE FOR CARBON MONOXIDE AT STATION 14049
1977
0 2 4 6 ppm
Calm
ppm: parts per million
0 1 2 3 4
Scale in miles

APPENDIX VII

OXIDES OF NITROGEN

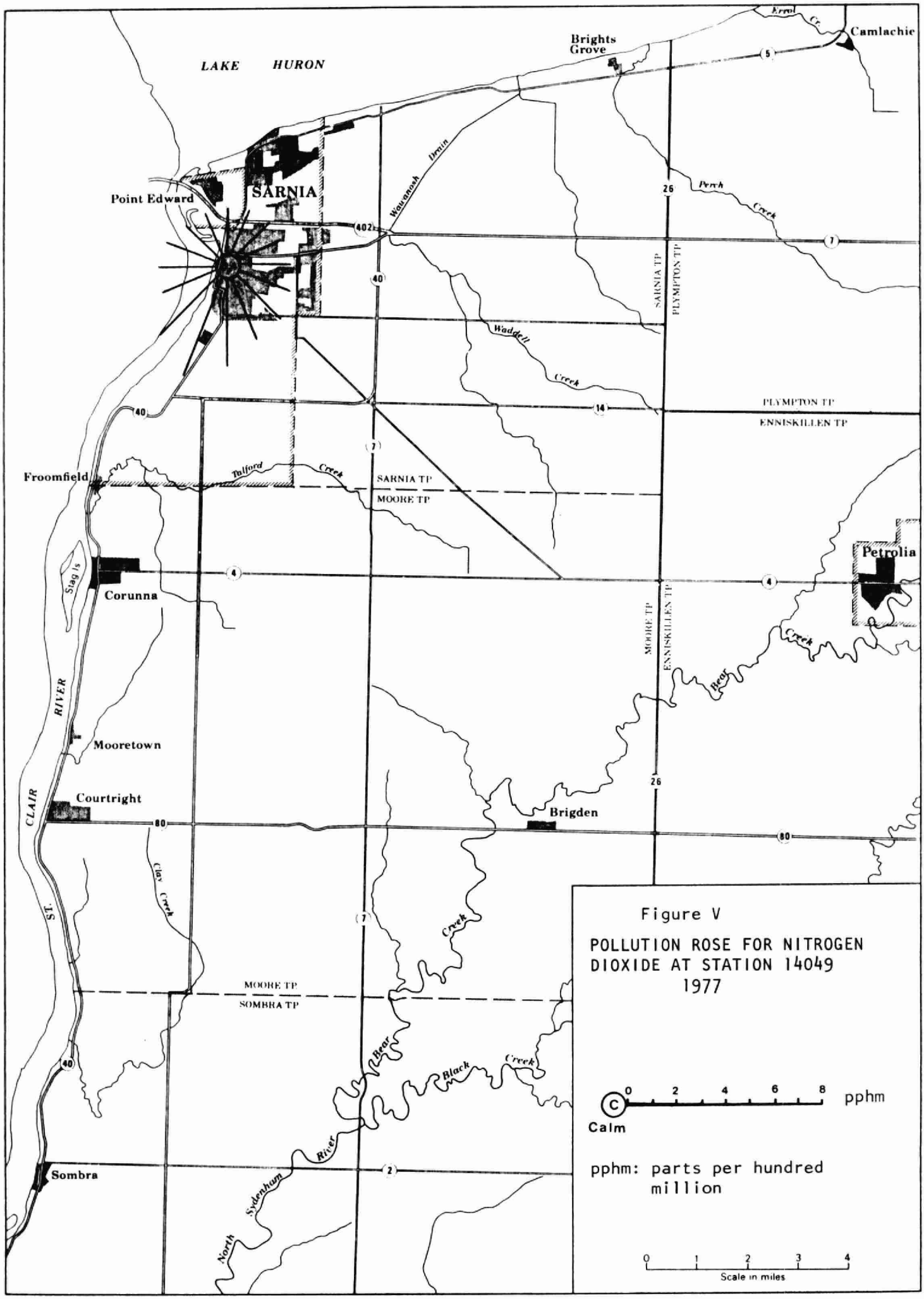
TABLE XIII - SUMMARY OF DATA FOR OXIDES OF NITROGEN AT STATION 14049

1972 to 1977

PARAMETER \ YEAR	1977	1976	1975	1974	1973	1972
Annual Average Concentration (ppm) For:						
Nitrogen Oxides	0.05	0.05	0.05	*	**	
Nitric Oxide	0.02	0.02	**	**	**	
Nitrogen Dioxide	0.03	0.03	0.03	0.02	0.03	*
Percentage of Nitrogen Dioxide Values Above Criteria Established for:						
1-Hour	0	0	0	0	0	0
24-Hours	0	0	0	0	0	0

* Insufficient Data

** Not Data


LAKE HURON
Brights Grove
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Camlachie
SARNIA
Point Edward
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MOORE TP
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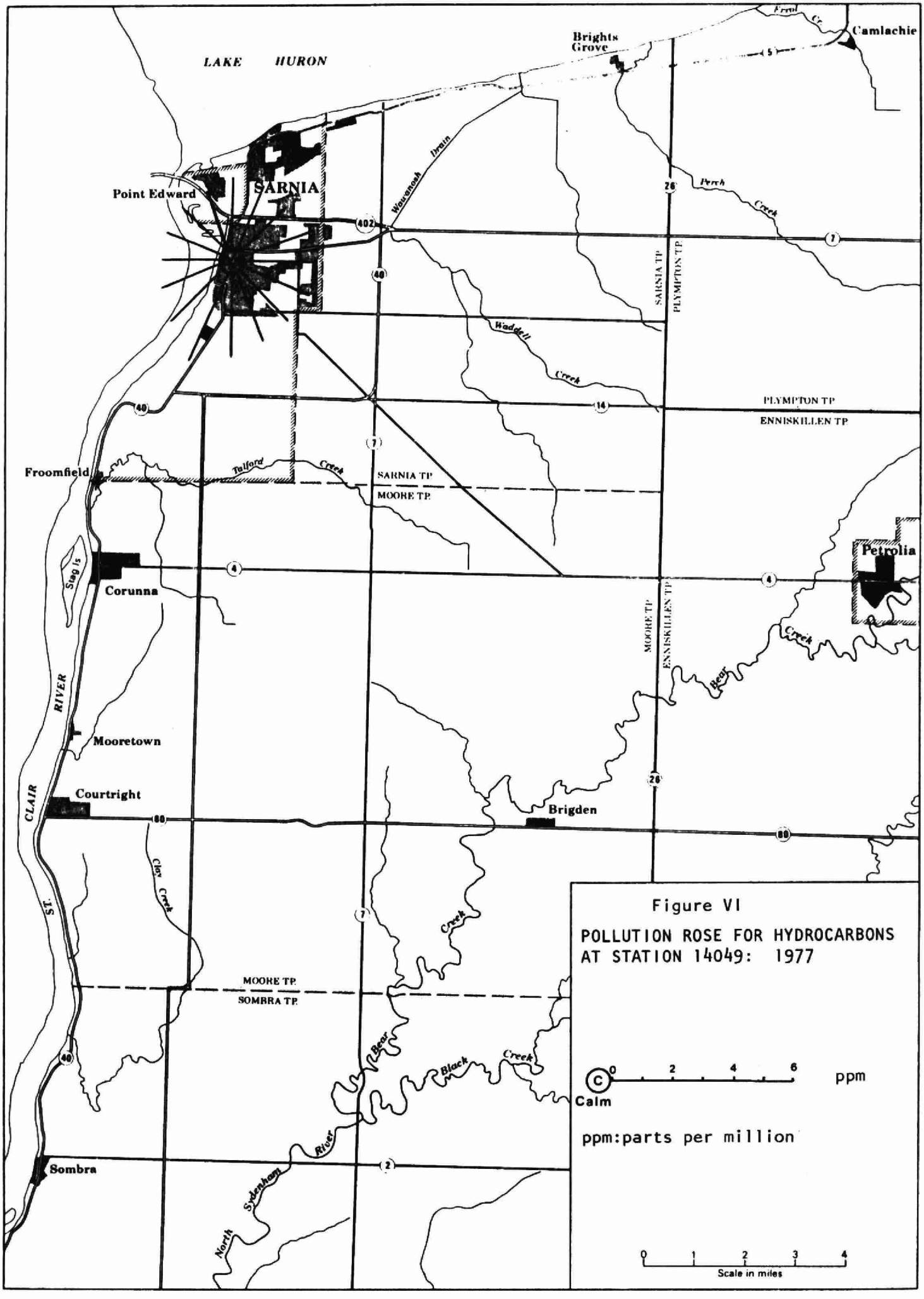
Stag Is
Corunna
MOORE TP
ENNISKILLEN TP
Bear Creek
CLAIR RIVER ST.
Mooretown
Courtright
Brigden
Clay Creek
Creek
MOORE TP
SOMBRA TP
Bear Creek
Black Creek
Sombra
North Sydenham River
Figure V
POLLUTION ROSE FOR NITROGEN DIOXIDE AT STATION 14049
1977
0 2 4 6 8 pphm
C
Calm
pphm: parts per hundred million
0 1 2 3 4
Scale in miles

APPENDIX VIII

HYDROCARBONS

TABLE XIV: SUMMARY OF DATA FOR HYDROCARBONS AT STATION 14049: 1972 to 1977.

Year	Annual Average Concentration (ppm)
1977	2.4
1976	2.3
1975	2.6
1974	2.8
1973	2.3
1972	2.3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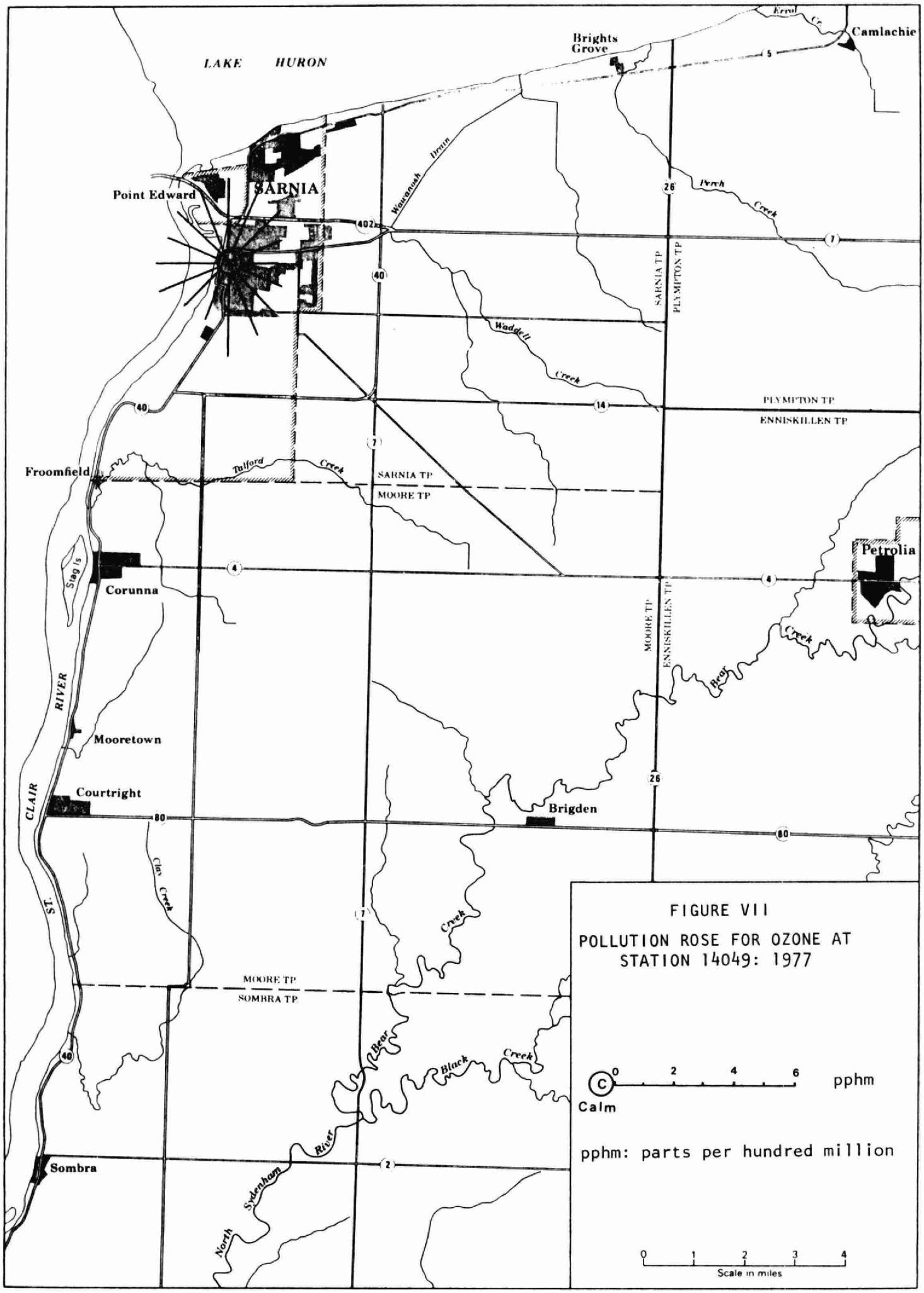
Camlachie
Point Edward
SARNIA
Waewanosh Drain
Perch Creek
SARNIA TP
PLYMPTON TP
Waddell Creek
PLYMPTON TP
ENNISKILLEN TP
Froomfield
Telford Creek
SARNIA TP
MOORE TP
Petrolia
Corunna
Stag Is
CLAIR RIVER ST.
Mooretown
MOORE TP
ENNISKILLEN TP
Bear Creek
Courtright
Brigden
Clay Creek
Creek
MOORE TP
SOMBRA TP
Bear Creek
Black Creek
Sombra
North Sydenham River
Figure VI
POLLUTION ROSE FOR HYDROCARBONS
AT STATION 14049: 1977
0 2 4 6 ppm
Calm
ppm:parts per million
0 1 2 3 4
Scale in miles

APPENDIX IX

OXIDANTS

TABLE XV - SUMMARY OF DATA FOR OZONE:
1974 to 1977

STATION NUMBER	YEAR	ANNUAL AVERAGE (ppb)	PERCENTAGE OF VALUES GREATER THAN 1-HOUR CRITERION (80 ppb).
14049	1977	20	1.0
	1976	19	0.7
	1975	24	1.9
	1974	18	1.1
14118	1977	27	2.6


LAKE HURON
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SARNIA TP
PLYMPTON TP
Waddell Creek
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ENNISKILLEN TP
Froomfield
Tulford Creek
SARNIA TP
MOORE TP
Petrolia
Stag Is
Corunna
MOORE TP
ENNISKILLEN TP
Bear Creek
CLAIR RIVER
Mooretown
Courtright
Brigden
Clay Creek
ST.
Creek
MOORE TP
SOMBRA TP
Bear Creek
Black Creek
Sombra
North Sydenham River
FIGURE VII
POLLUTION ROSE FOR OZONE AT STATION 14049: 1977
0 2 4 6 pphm
Calm
pphm: parts per hundred million
0 1 2 3 4
Scale in miles

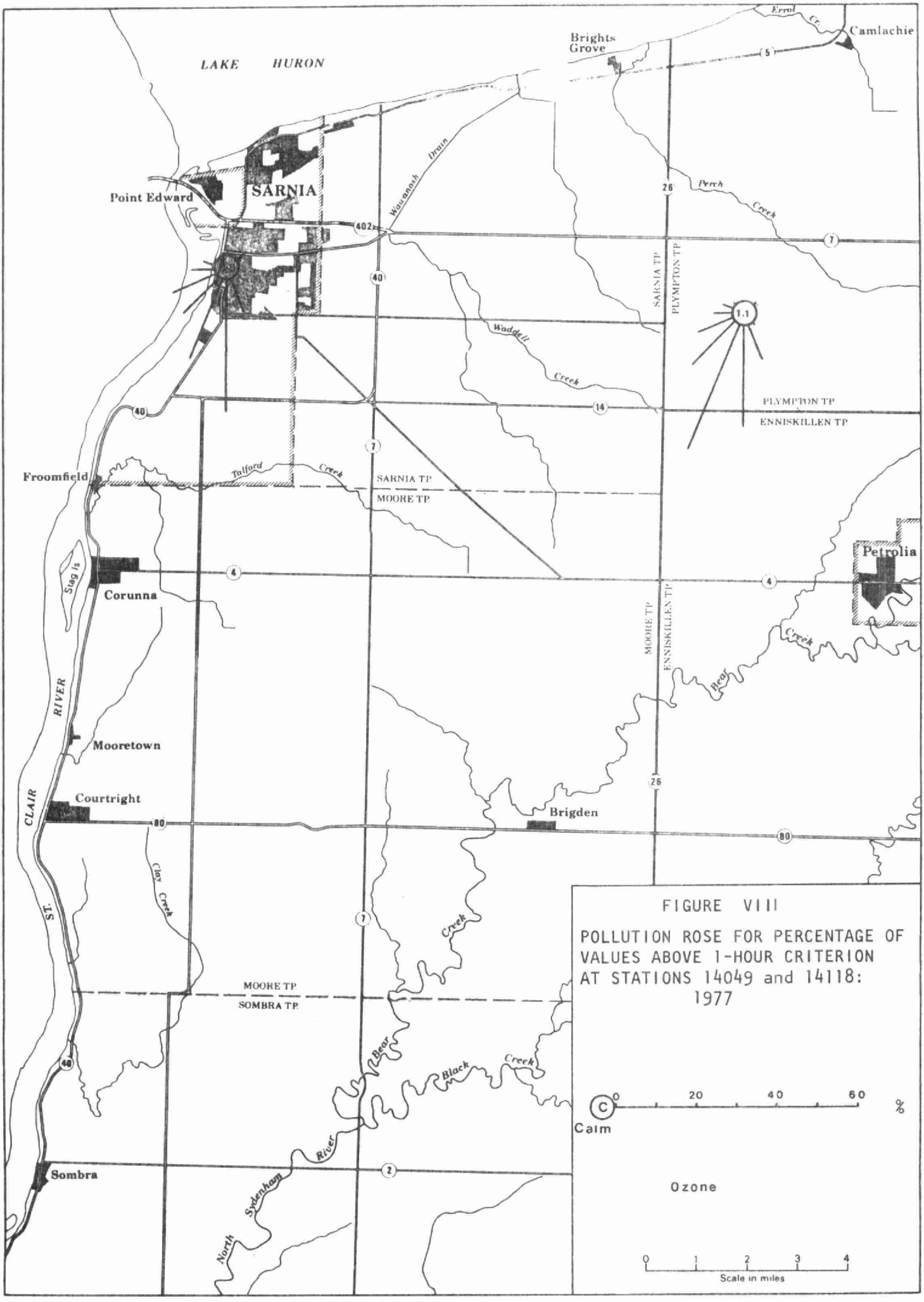

FIGURE VIII

POLLUTION ROSE FOR PERCENTAGE OF VALUES ABOVE 1-HOUR CRITERION AT STATIONS 14049 and 14118: 1977

APPENDIX X

FLUORIDATION RATE

TABLE XVI - FLUORIDATION RATES
(ugF/100 cm^2/30 DAYS)
FROM 1972 to 1977

YEAR	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	ANNUAL AVERAGE
STATION 14049													
1972	85	60	22	32	28	56	29	80	20	23	17	45	41
1973	55	50	60	65	65	100	75	60	40	70	55	55	63
1974	67	56	44	66	18	ND	48	ND	50	44	66	80	54
1975	31	39	19	18	ND	29	34	34	22	74	44	31	34
1976	37	53	36	11	18	24	6	42	32	27	29	31	29
1977	55	40	32	16	34	14	43	32	26	46	43	74	38
STATION 14004													
1976	ND	ND	ND	ND	ND	46	38	74	48	39	21	40	44
1977	42	23	53	32	78	31	ND	79	112	29	104	50	58

NOTE: 1) ND - NO DATA
2) UNDERLINED VALUES EXCEED DESIRABLE AMBIENT AIR CRITERIA

Date Due

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